Extremes should be avoided in all cases. For summer air conditioning, low supply-air temperatures result in larger heat gains to the air passing through the ducts, as well as in poor control. Too high a supply-air temperature may result in excessive initial and operating costs. Suggested limits for the temperature differential are from 12 to 25 deg, the actual selection being based on the requirements of the particular case. For winter air conditioning, too high supply-air temperatures result in excessive heat losses from the ducts and stratification within the room unless thorough mixing is assured, while too low supply-air temperatures may cause drafts, high operating costs, etc. Suggested limits are from 15 to 35 deg. There can be no set rule, and each case should be judged according to its particular requirements of the installation.

Reference may be made to Chapter 20 for further discussion of the most satisfactory design difference between the entering air temperature and volume in relation to the desired room condition.

UNITARY-CENTRAL SYSTEMS

Many different types of central air-conditioning systems with room units of various designs have been developed for multi-room buildings, such as office buildings, hotels, and hospitals. The primary object in using these systems is to save space by reduction of duct sizes or by entirely eliminating ducts. In new buildings, small ducts may reduce the overall building height; in existing buildings, the use of small ducts is frequently imperative and may even play a decisive role in the acceptance of air conditioning for these buildings. Also, multi-room buildings frequently require a high degree of zoning or individual room control, which the systems must supply.

These buildings usually have a large perimeter relative to the floor area. Air-conditioning units are usually installed beneath the windows. Where the spaces to be conditioned extend a considerable distance from the outer wall into the interior of the building, as in some office buildings, a separate system or zone for the conditioning of the interior portions may be required. In these cases the interior system handles the relatively small and steady loads, due to such items as lights and people; while the exterior system must cope with the relatively large and variable loads imposed by sunshine and temperature difference through walls and glass. Descriptions of the four common unitary-central systems follow.

Induction Convectors—Low-Pressure Type

Induction convectors located in the room that is to be served, utilize a jet of primary conditioned air to mix with a stream of secondary room air as shown in Fig. 4. The mixture is discharged into the room through a grille at the top of the convector. Heating coils are located in the secondary-air stream. The output is controlled either by manually or automatically throttling the air jet. Heat may be supplied to the coil in summer as well as in winter. These induction convectors present several advantages. Since the secondary air stream is thoroughly mixed with the high-velocity low-temperature air stream before leaving the discharge outlet of the device, the resultant temperature of the mixture is satisfactory even though the primary air is introduced at a temperature too low for ordinary methods of distribution. One of these devices usually is provided under each window in place of the customary direct radiator, and combines the air-distribution system with the heating system. An air-conditioning system without induction convectors may require installation of direct radiation for maintenance of minimum temperatures during air-conditioning shut-down periods, but when induction convectors are used they may be selected with heating coils of sufficient capacity to maintain, by thermal circulation, a reasonable temperature when the primary-air supply system is shut off. The use of low-temperature, dehumidified air that has not been reheated or mixed with room air before delivery to the room, may permit a reduction in fan capacity and the use of smaller ducts. In some cases a bypass may be desirable in order to maintain the primary-air volume and to provide additional control. This system can provide a degree of zoning that is usually difficult with conventional design because the air delivered by each unit can be controlled individually. Selection of induction convectors should be made with due regard to noise level. The inductive capacity of the device increases with the jet velocity, but high jet velocities may result in objectionable noise.

The units are supplied with primary air from one or more central stations with the primary air providing all ventilation and handling the entire cooling load. The central apparatus is arranged in general conformity to Fig. 1 except that the central reheater is omitted since each unit has its own reheater. The controls are arranged to maintain a substantially-constant supply-air temperature equal to that required for maximum cooling. Final control is obtained by means of a room thermostat, or remote bulb thermostat in the unit having its measuring element in the recirculated-air stream. The controlling thermostat operates the coil supply valve and a damper operator on the primary-air damper in sequence. At maximum heating load the valve is wide open and the primary-air quantity is at a minimum. As the space temperature tends to rise, the valve is first gradually closed, then the primary-air quantity is gradually increased from minimum to maximum. Alternately the primary-air quantity can be kept constant while final control is achieved by the individual heating coils. If variable air quantities are to be handled by the primary-air fan, some form of fan-capacity control is necessary.

Induction Convectors—High-Pressure Type

Another type of induction convector, Fig. 5, employs nozzles that produce a high-velocity air jet without objectionable noise. The term, high pressure, is to some extent inaccurate, since the air pressure at the nozzles, while several times that used with a low-pressure induction convector, is still less than the total resistance pressure of a conventional central system. The high-velocity jet of primary air induces

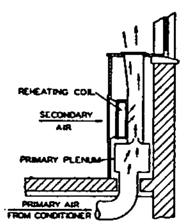

Fig. 4 .... Induction Unit (Low-Pressure Type)

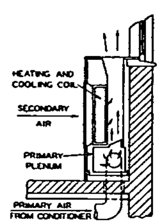

Fig. 5 .... Induction Unit (High-Pressure Type)

a flow of air from the room through coils located in the secondary-air stream and supplied with chilled water in summer and with hot water in winter. The chilled water removes a large portion of the sensible heat in summer and the hot water supplies the sensible heat loss in winter. The primary air is delivered at a sufficiently low dew point to compensate for the latent heat gain in summer. In winter the primary air is supplied at a sufficiently high dew point to take care of latent heat losses. Control of temperature is obtained by throttling the water quantity supplied to the secondary coil. The required flow of primary air is greatly reduced due to the fact that a portion of the sensible heat load is carried by the secondary air stream. Since the primary quantity is small, very high velocities can be maintained in the supply ducts without requiring fan power in excess of that for a conventional system. Therefore, the supply ducts or pipes can be very small and can be run in chases, or furred in at columns along with the water pipes. The primary air is treated in the usual manner to reach the required dew point and a surface or spray dehumidifier or a dehydrator may be used. The primary-air quantity is sufficient for ventilation purposes and frequently consists entirely of outdoor air.

Fig. 6 shows the general arrangement and control of the system. The operation of the controls is as follows:

The final temperatures in the spaces are controlled by individual valves, either automatic or manual, which throttle the flow of secondary water to the unit coils. Where automatic valves are used, the thermostats are of the heating-cooling type so that a rise in room temperature opens the valve when cold water is circulated and closes the valve when hot water is being supplied. Thermostat T1 controls the preheater steam valve V1 to maintain a temperature of about 45 F leaving the preheater. Thermostat T2 controls the maximum outdoor-air and return-air dampers so that the air entering the dehumidifier is maintained at 50 F whenever outdoor air conditions permit.

During the heating cycle, thermostat T3 and valve V2 are inoperative so that cool primary air is supplied to the units but at the same time thermostat T6 operates valve V4 so that the secondary water is heated. Thus the combination of cool primary air and hot secondary water can provide heating or cooling as required. The primary pump and water cooler are inoperative.

When the outdoor air is no longer suitable to provide sufficient cooling through the primary air system (typically about 50 F) the system is changed from heating to cooling operation. The primary pump is started and supplies chilled water to the dehumidifier. Thermostat T4 controls mixing valve V3 so as to maintain the secondary water at temperatures in the range of 50 to 55 F. At outdoor temperatures below 80 F thermostat T3 regulates reheater valve V2 so that warm primary air is supplied at the same time that cold secondary water is fed to the units. The changeover from heating to cooling is usually manual and the exact time is not too important because both heating and cooling are available in either case. During the cooling cycle, thermostat T7 acting through thermostat T3 readjusts the primary-air temperature downward as the outdoor-air temperature increases from the changeover point to about 80 F so that above this temperature the primary air is at the apparatus dew point.

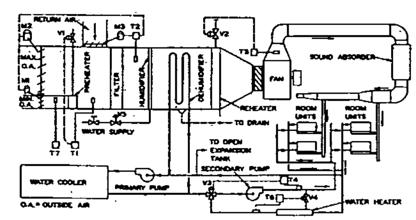

Fig. 6 .... Typical Induction Unit System

In some buildings the primary-air system and water circuits are zoned according to exposure, but because both heating and cooling are available at the units whenever either is needed, such zoning is not always used.

All-Air High-Velocity Systems

All-air high-velocity systems are air-conditioning systems in which the duct velocities and static pressures are such that special control and acoustic equipment is required for proper introduction of the conditioned air into the space to be served.

All-air high-velocity duct systems are of either single-duct or dual-duct types.

The *single-duct system* is usually zone controlled. The single supply temperature is established for each zone and therefore variations in individual rooms must be compensated by throttling the air supply volume. Throttling is limited to the lowest air quantity required for ventilation and for satisfactory air distribution which depends to a large degree on the performance of the type of air outlet used.

Dual-duct systems deliver the entire air supply to cold- and warm-air supply ducts, from which it is distributed into air-mixing valves or acoustic terminal devices. (A mixing valve is a mechanical device that serves to proportion air from a cold-air duct and a warm-air duct into a common outlet, or duct. An acoustic terminal device is an air distribution unit consisting of an air valve, acoustical attenuation chamber, and an air outlet.)

The proportion of cold air and warm air delivered to the air-mixing valves or acoustic terminal device is thermostatically controlled. This control, together with controls for maintaining fixed volumetric delivery, results in a constant volume of air supply at a temperature that satisfies the load.

Mixing valves may be used to deliver large quantities of mixed or blended air at high velocity to a single-duct system equipped with acoustic terminal devices supplying the needs of an entire zone or area. The air coming from the mixing valve may also be reduced in pressure (either in the mixing valve itself or by means of an additional valve or damper) so that it can be distributed by a conventional low-velocity duct system. In this case, noise attenuation is accomplished by a length of lined duct, or by a separate noise attenuator installed after the mixing valve.

For greater flexibility, acoustic terminal devices which usually are equipped with one air outlet only, may discharge into a low-velocity rigid or flexible duct equipped with several air outlets.

Refer to Chapter 21 on Air Duct Design for a discussion of the design of high-velocity ducting.

The general arrangement of a typical dual-duct system is shown in Fig. 7. In some arrangements, two supply-air fans are used with one fan supplying the cold-air duct and the other the hot-air duct. The warm-air fan handles only recirculated air so that operating economy is slightly improved.

The maximum outdoor-air damper and the preheater are controlled as in Fig. 1 so that when the temperature of the